CONCEPTIONAL DESIGNS FOR A MARS TUMBLEWEED

H. C. Hanrahan(1), D. A. Minton(2), F. R. DeJarnette(3), I. A. Camelier(4), M. H. Fleming(5)

(1) Fred J. Carnage GT Magnet Middle School, Raleigh, NC, USA; hhanrahan@wcpss.net
(2) NC State University, Raleigh, NC, USA; daminton@unity.ncsu.edu
(3) NC State University, Raleigh, NC, USA; dejar@ncsu.edu
(4) Universidade da Beira Interior, Portugal; camelier@ubistb.ubi.pt
(5) NC State University; Raleigh, NC, USA; mhflemin@eos.ncsu.edu

ABSTRACT

Mars Tumbleweed Project: Designing a Wind-driven Sensor Device that will take atmospheric and soil measurements on Mars with the goal of sending data back to Earth and discovering life on the planet. Mars Tumbleweed was introduced to 100 sixth grade science students at Fred J. Carnage Middle School in August 2002. The project was broken down into four major phases: Parachute Design, Parachute Testing, Tumbleweed Design, and Tumbleweed Testing. Competency Goal 3.05 of the NC Standard Course of Study: The learner will build an understanding of the Solar System by identifying technologies used to explore space was reached. The four concepts introduced to the sixth grade students were the Tumblecup, Box-Kite, Wedges, and Dandelion. After testing the Tumbleweed Class Demonstrators, TCD, the modified Box-Kite had the best results. When compared to NC State University's Tumbleweed Earth Demonstrator, TED, the TCD was simply a miniature TED that the college students designed.

1. INTRODUCTION

Mars Tumbleweed, an inquiry-based project, that allows the sixth grade science students of Fred J. Carnage GT Magnet Middle School to actively collaborate in cutting-edge research and design with NASA and NC State University. Education is leading away from the memorization of facts and toward an understanding of how to retrieve and make sense of facts. Through inquiry-based learning, students seek to understand by asking questions. By doing research, a deeper understanding of the subject is gained. The students then begin to apply that knowledge.

Inquiry-based learning prepares students for success in the "real-world," as they begin to see patterns and connectivity in all areas of learning. They begin to understand that science is the application of math that has the potential to change the future of mankind. For example, the great space race between the Soviet Union and the United States began during the Cold War and had a profound historical impact on those two countries as well as the space program itself. Inquiry-based learning allows the students to make this connection between the various subjects, therefore deepening their understanding of the history of space flight.

Destination: Mars is an inquiry-based curriculum designed to join the four sixth grade science NC Standard Course of Study goals into one theme: the study of Mars. As the students research the lithosphere of the red planet, they discuss the building blocks of life and whether or not life, past or future, will ever be found on Mars. This discussion segues into the Tumbleweed Project.

At NASA Langley Research Center, the Tumbleweed idea originated from a discussion concerning Mars Pathfinder. Landing on the Martian surface, Pathfinder was moving (bouncing) along very well on the surface of Mars before the airbag landing system was deflated. Two NASA scientists, Jeff Antol and Greg Hajos, from the Spacecraft and Sensors Branch (SSB) came to Fred J. Carnage Middle School to introduce the Mars Tumbleweed. From beach balls rolling across the stage to a real tumbleweed blowing in the wind, the students were inspired to ask questions and generate new ideas for the NASA scientists to ponder. A very inquisitive student, Alfred, impressed the NASA scientists with his questions, "Wouldn't you want to make the vehicle more streamlined and have it create less drag?" While other students responded with similar comments and expressed their creative thoughts, Alfred's imagination was fueled to ask, "What about making the tumbleweed out of carbon fibers?"

Fig. 1. NASA scientists visit the sixth grade at Fred J. Carnage GT Magnet Middle School.

The Mars Tumbleweed Project, which began with inquiry, was taken to great heights as students began asking questions, seeking answers and then applying those answers to “real-world” current research. When asked at the end of the project to determine the most meaningful part, most students agreed that working alongside NASA and NC State University to design a brand new spacecraft never before created was “awesome.”

2. PARACHUTE DESIGN

Due to the knowledge level of sixth grade students, a reverse approach was utilized. By first designing the parachute for the deployment of the Tumbleweed, the students were able to determine the maximum weight of their tumbleweed. The students started with a parachute design using a washer, an 8 ½ inch X 11 inch piece of paper, and two pieces of string. After forming their “paper parachutes,” they dropped them off a landing by the staircase.

Fig. 2. Dropping “paper parachutes.”

Times were recorded and the student whose parachute had the best time received a prize. The students then theorized about what made that student’s parachute fall slower then all the others. There appeared to be no solution.

Fig. 3. Creating the parachutes.

From the “paper parachutes,” the students discussed which material would make their tumbleweed drop the slowest. Some examples of over fifty materials listed were pillowcases, sheets, nylon, garbage bags, etc…

Size was an issue as well. Students were told that the parachute had to be no smaller than 36 inches in diameter. Now they ran into the following problem: ”How do we make a circle with an 18-inch radius without a compass that big?” They learned how to make a human compass using a marker, yardstick and string as pictured below applying their newly acquired problem-solving skills.

Fig. 4. The human compass.

3. PARACHUTE TESTING

Once the parachutes were created, it was time to test them. This step was extremely important because it was from this step that the mass of their tumbleweed would be determined. To test the tumbleweeds, each student brought in a small bottle of water. Students used the water bottle to add or take away weight, depending on how rapidly their parachutes dropped. Understanding the landing that was used to drop the “paper parachutes” was too short; the parachutes were dropped out of a third story window. Before students dropped their parachutes, however, the mass was recorded. They then dropped the parachutes and their times were recorded.

Fig. 5. Parachute testing using a water bottle.

Based on the results, students added or took away water and repeated this activity several times until they were satisfied with their results.

Several students decided to change their parachute material to a garbage bag as those seemed to work the best. In the picture above, the student used a bed sheet, which also had really good results. The student realized the mass of the water bottle had to be just right or the parachute would become inverted or twisted and crash to the ground. This was determined by trial and error; yet another form of inquiry.

4. TUMBLEWEED DESIGN

After the students had determined the "perfect" mass for their parachutes, it was time to begin the design of the tumbleweed.
Four design concepts were introduced to the students as pictured below: the Tumblecup, Box-Kite, Wedges, and Dandelion.

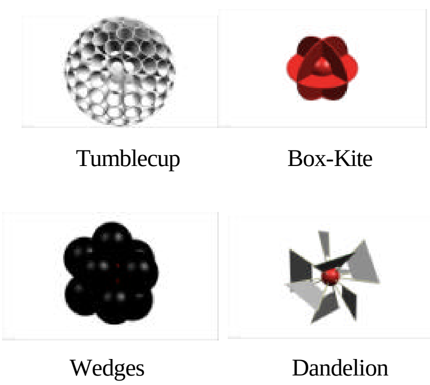


Fig. 6. Four design concepts.

Students were told they could use one of these designs, modify one of them, or create their own design. Many chose a modified Tumblecup design using toothpicks and a foam ball instead of cups. One student used straws and a foam ball. Another group chose to use the Wedges design because it was light and would "move better in the wind." One lone student however decided to make a modified Box-Kite using a foam ball, straws, pipe cleaners and paper (as sails).

Fig. 7. Modified Tumblecup

Fig. 8. Modified Box-Kite

5. TUMBLEWEED TESTING

With the tumbleweeds complete, it was time to test them. It was already decided that the students would use the floor as their "Mars" rolling surface with a fan as the propulsion method. However, the student's quickly became frustrated when their tumbleweeds went outside the boundaries of the airflow. After much consideration, the students came up with the idea of a wind tunnel. Flipping the students' tables on their sides and placing them in rows with a fan at one end formed the wind tunnel. The original wind tunnel was eight tables long and the floor was labeled in decimeters for distance.

Fig. 9. Mock-up of original wind tunnel

The students placed their tumbleweeds in front of the fan and then the fan was turned on "high." The modified Tumblecup did well as long as it remained rolling. Once it stopped, it often would not start again. The modified Tumblecup as shown in the picture above had the best distance with the smoothest trip. However, sometimes it would come to rest between the straws and would not move again. The students also discussed a disadvantage of the modified Tumblecup design. If the pieces came off, then it would not work properly.

The wedges performed well, but the balloons began popping and it would also move too fast, not allowing it to take accurate measurements if it were a real tumbleweed.

The modified Box-Kite had the best distance and made the most sense to the students. Unlike the modified Tumblecup, if the modified Box-Kite came to a stop one of the sails would pick up the wind and continue to move the Tumbleweed down the wind tunnel.

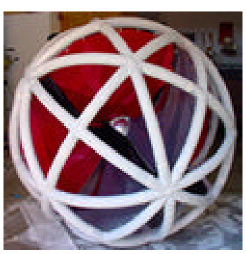
6. CONCLUSION

Once the project in class ended and students reflected;

the general consensus was that they enjoyed the project and learned a lot about what it takes to create a vehicle from scratch based on the way nature works. They gained an understanding of physics through the creation of their parachutes and the testing of their tumbleweeds. They learned about the Martian soil and thin atmosphere. Most importantly, they learned how to generate questions, research the answers and solve various problems.

The two tumbleweeds that moved the furthest distance in the wind tunnel and were judged to be the best designs by all of the students were put on display at the Festival of Flight in Fayetteville, North Carolina, USA, May 17-25, 2003 along with NC State University's design. The students who created those two Tumbleweeds were shocked to see how alike their design was to the NC State student' design.

Fig. 10. Fred J. Carnage Tumbleweed "winners go to NC State University to compare Tumbleweeds.



NC State University Fred. J. Carnage GT Magnet

Fig. 11. Comparison of tumbleweed designs.

Plans for future classes include designing a "Martian" surface complete with rocks and pebbles for more realistic conditions. Eventually, sensors will be added to the project.